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JPRS: 4717

22 June 1961

PROBLEMS OF SPACE MEDICINE

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- CZECHOSLOVAKIA -

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CSO: 1842-S

PROBLEMS OF SPACE MEDICINE

--Czechoslovakia--

[Following is the translation of an article by Vladimir Malcik in Tvorba (Creation), Vol XXVI, No 17, Prague, 27 April 1961, pages 387-388.]

Space medicine has a very extensive work content. In substance it deals with problems of selecting astronauts and with questions of the life, health, and work of the astronaut at the start, the flight and return of the space ship, his stay in space and on the surface of celestial bodies, and also problems of securing his life in a difficult situation. It studies, therefore, how the various conditions of space flight affect the organism and investigates the possibility of providing the astronauts with a proper environment from a physiological standpoint. For this purpose it uses the findings of other medical fields and the biological sciences.

Space medicine is the direct continuation of aviation medicine. The basis of both aviation and space medicine is the study of the physiology and pathology of flight. The aviator finds himself during flight in an environment substantially different from the one in which man developed and in which the organism was able to adapt to changing conditions. In aviation medicine two general periods can be recognized: the period of classical aviation medicine, which starts around 1879 with the work of Paul Bert and extends into our time, and the second period which is marked by the transition to space medicine. We are now witnessing its birth.

Some problems solved in the period of aviation medicine are still important in the period of space medicine, but it is necessary to broaden and complement them substantially. What are they?

The influence of noise is a very pressing problem. The noise intensity of a rocket reaches 200 db, and in the space allotted to the crew one must expect an intensity of 140 db. This is above the threshold of pain. It is necessary to remember that besides directly causing damage to the hearing organism, noise affects the activity of the central nervous system and, through it, the function of numerous organs.

Vibrations are one of the biggest health problems in rockets. Vibrations of several tenths of a millimeter are already hard to bear, but the amplitude in rockets is much higher. Vibrations have the effect of increasing the pulse rate, raising the blood pressure,

and increasing the metabolic exchange. Sometimes neurovegetative disturbances such as dizziness and nausea appear. Long-term vibration effects influence hearing. Sight is very strongly affected by vibrations. Movement of an object on the retina occurs even when the eye tries to focus on it; at higher frequencies (60 Hz), the eye begins to tremble, visual acuity drops, the balance of eye muscles is disturbed, and depth vision changes. A person exposed to vibrations for a longer time experiences total fatigue.

The influence of gravitational pressure due to acceleration and protection against it must be solved with regard to the fact that a much longer and faster acceleration will be experienced. The influence of acceleration on the organism depends to a considerable degree on the direction of the acceleration in relation to the body. We differentiate leg-head, head-legs, and oblique acceleration. The body stands oblique acceleration best, i.e., in the direction of chest-back or the opposite. Head-legs acceleration causes a shifting of the internal organs and blood. The heart muscle then cannot provide adequate blood pressure in the brain, and disturbances of vision and eventually even fainting may take place.

Resistance against gravitational pressure is increased with good physical preparation, exercise in the centrifuge, the anti-G suit and the position of the body. For this reason the construction of a special anti-G capsule was proposed; it would always rotate in such a way that the person in the seat would be in an oblique position with regard to the direction of acceleration.

The question of efficiency and the closely connected question of fatigue must eventually be solved at variance with aviation medicine principles through a more extensive use of pharmacological means.

Orientation in space presents problems which are getting more difficult. In man, orientation is the result of the cooperation of several senses, because man has no special organ for orientation. Orientation in flight away from the earth can be divided into the orientation of the crew inside the spaceship by means of the senses and the orientation within interplanetary space by technical means. Orientation within the ship may have various difficulties. Orientation in space by sight depends on information from other senses; thus, deceptive impressions and illusions may arise.

Hygienic problems of clothes present a problem of considerable importance. The flight suit must protect the astronaut against a lack of oxygen and against caisson disease, it must provide a complete regeneration of air, contain an oxygen supply and have radio-communication equipment, and it must provide for eating, elimination and sleep. In its construction the effects of gravity and radiation must be taken into consideration.

Problems of nutrition are now found in an area as yet little explored. Food supply on short flights will present no difficulties,

and appropriate ship rations of food and water can be assured. For long space flights the problem of food has not yet been solved. The weight of the provisions is the decisive factor. One possibility which has been considered is to supply food by way of concentrated tablets. Another proposal suggests regeneration of waste products. The example is the circle of life on earth, where actually no waste exists. What is waste for one organism is food for the other. This circle would have to be imitated.

Two ways are possible: the biological, through which substances are created from the waste of plants and animals, and the biochemical, where substances are created from waste artificially. Algae play an important part in this problem. Experiments have been performed chiefly with the alga *Chlorella*. Algae contain about 48% albumen, 8% fats, 4% minerals, and 40% carbohydrates. Basically, the following requirements have to be fulfilled by algae: first, production of oxygen using carbon-dioxide; second, their fast growth. Practice is still far from satisfying these requirements. So far, oxygen obtained from algae has sufficed for one mouse for 27 days.

To these problems new ones are being added with which classical aviation medicine has not dealt at all. Let us discuss the most important ones.

The effect of the state of weightlessness will be a steady factor in space flight for long periods of time. The first knowledge about the effect of weightlessness on a living organism were obtained from rocket flights, when in the upper sector of the parabolic course the state of weightlessness was achieved for about 30 seconds. From animal experiments it was learned that the basic physiological functions of the organism (i.e., breathing, frequency of heart beat, blood pressure) were not substantially changed. However disturbances of coordination of movements and of orientation with regard to the cabin were noted. In experiments with people it was found that space orientation is improved by strapping them to the seat. Further experiments showed that liquids assume a spherical shape in the state of weightlessness and will cover the surface of solid bodies which surround them. The heated air in the cockpit does not rise, so that artificial air circulation will have to be provided.

Influence of the gaseous environment. The Soviet space ship had the same air pressure and air composition as on earth. An air composition quite different is being considered, for instance 60% oxygen, 20% helium, and 20% nitrogen. A high oxygen content is important with regard to good blood saturation, which would also make it possible to reduce the pressure in the cockpit and reduce the danger of the consequences of explosive decompression. Helium is also added with regard to the possibility of explosive decompression because it is more inert than nitrogen and would not be released as easily into the tissues and blood. This way the danger of the con-

sequences of a sudden pressure-drop in a stressful situation would be decreased. Of course, the question remains what the influence of a high oxygen and helium content would be on the human organism over a long stay in this artificial atmosphere, lasting months or even years.

Another question is the increased carbon dioxide content which is exhaled by man. This problem is being adequately studied in submarines, where there is .1 - .2% carbon dioxide in the atmosphere. The maximum tolerable concentration is 2%. At a higher carbon dioxide content there appears a feeling of suffocation, the blood pressure rises, and the activity of the central nervous system is depressed.

The effects of radiation present a real danger on space flights. Cosmic rays are charged material particles which have an energy on the order of tens of billions of electro volts. This is enough to affect the atoms of all substances. In these cases an electron is knocked off the atom and an electrically neutral atom changes in a positively charged ion. Such ionization occurs also when cosmic rays hit tissues of living organisms. Ionization disturbs the normal biological processes and damages cells and tissues. With intensive ionization the so-called radiation sickness occurs. Cosmic radiation has both immediate and delayed effects. The immediate changes are in the dissolution of water molecules and damage to various substances and enzymes important for life. Delayed effects show themselves by causing malignancies and in disturbances of blood formation. Radiation can also affect progeny, although no obvious signs of damage to the organism may be present.

Changes in periodicity. Man has a steady, 24-hour rhythm which underlies a steady arrangement of functions. By changing the rhythm, disturbances appear. Only after a certain time will man become accustomed to another rhythm. In an interplanetary space ship there is no change from day to night. This may affect efficiency. Steady activity will exist in a space ship, and this will be an added hardship. A proper regimen is still being tested.

Influence of solitude and isolation is a factor which must be taken into consideration in space travel. On flights at great heights a feeling of solitude, distance, anguish, separation from the world prevails. It is spoken of as a feeling of separation. The ability of the central nervous system depends on the input of a certain amount of stimulations. If this flow of stimulation is limited, a depression takes place and efficiency is reduced. Behavior also changes: people are emotionally unstable, temper flare-ups appear, the ability to think systematically is lost.

Questions of hygiene include a series of problems. A special chapter is the hygiene of skin and clothing. One must remember that the astronaut will for several reasons not be able to wash. First, there is a lack of water: it will be used only to maintain life. The astronaut will not be able to take off the flight suit.

With this are connected elimination and the disposal of waste materials. The astronaut will have in the flight suit his own microclimate. Under the flight suit various substances will accumulate which may cause itching and various skin affections.

For these reasons, intensive work is necessary with these problems. Here particularly the importance of cooperation of the various medical specialties is obvious, although some of them seemingly are quite distant from astronautic problems. In the CSSR, the importance of the participation of the different medical fields in space medicine has been properly understood. Particularly in dermatology, intensive work on some serious problems is being done.

This outline of the problems of space medicine is not and cannot be complete. I have listed only the most pressing problems.

Medicine occupies to a certain extent a special position among the scientific disciplines which share in solving the problems of space travel. Frequently it does not need any special experimental conditions. Many problems can be solved in our environment, and the physicians in the Commission for Aviation and Space Medicine at the Physiological Section of the Czechoslovak Medical Association of J. E. Purkyne take advantage of this possibility. We hope that with this work we will contribute to the development of this new scientific field -- space exploration -- and will thus share in the creative effort of Czechoslovak science.